Vernier SensorDAQ®

User's Manual

Measure. Analyze. Learn.™

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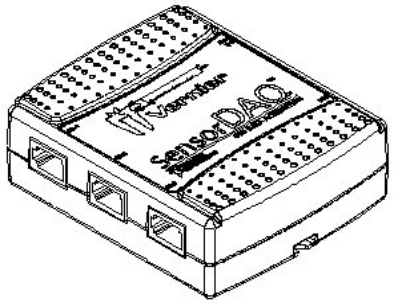
What is SensorDAQ?

The SensorDAQ® interface provides connectivity between Vernier or custom sensors and a Windows computer running LabVIEW software. More than 50 Vernier sensors are available for use with the SensorDAQ.

You can also combine the use of sensors connected to the SensorDAQ with the output of Vernier's Digital Control Unit (DCU) or the SensorDAQ's screw terminal for control projects. Examples include alarm systems and temperature-controlled environments.



By following this guidebook, you will learn to:

- Set up and collect data using Vernier sensors.
- Find sample programs.
- Access the SensorDAQ palette.

SensorDAQ Equipment List

The SensorDAQ package contains the following equipment:

- SensorDAQ interface
- User's Manual
- Vernier Voltage Probe
- CD containing SensorDAQ files
- USB cable

Quick Start

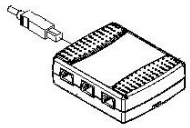
Install National Instrument Software

Install National Instruments LabVIEW software and device driver software.

1. Install National Instrument's LabVIEW software. If LabVIEW is already installed on your computer, check the version of LabVIEW you are using.
2. If you are using a version of LabVIEW that is not LabVIEW for Education or LabVIEW Education Edition, you will need to install the SensorDAQ driver (NI-DAQmx) and reboot your computer. This software is included with LabVIEW or can be downloaded for free from www.ni.com.

Connect Equipment

3. Connect the USB cable to SensorDAQ.



4. Attach the other end of the USB cable to any unused USB port on your computer.
5. If the NI-DAQmx driver software is properly installed the computer should provide a "Found New Hardware" message and the SensorDAQ LED next to the USB cable port on the SensorDAQ should be blinking.

Install the SensorDAQ Files

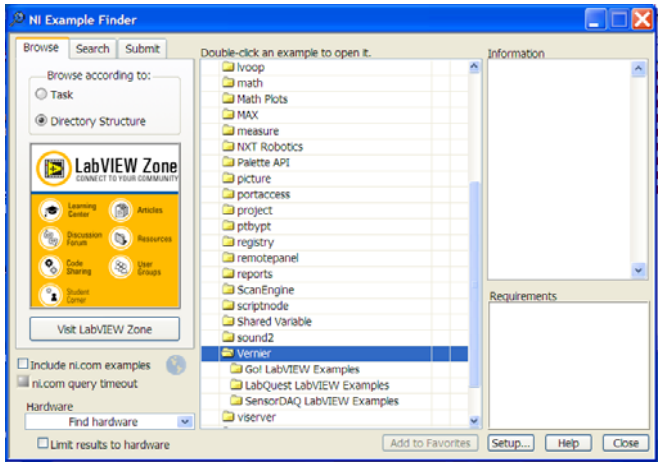
- LabVIEW for Education
    1. The SensorDAQ files are automatically installed with this version of LabVIEW, so no action is required.
- LabVIEW 2009 (or Education Edition), 2010, 2011
    1. Insert the SensorDAQ CD
    2. Open the LV2009, LV2010, or LV2011 folder, depending on the version of LabVIEW you have installed.
    3. Double click on the file called Vernier4LV.exe.
- LabVIEW 8.2, 8.5, 8.6
    1. Insert the SensorDAQ CD

2. Open the LV8.2 LV8.5 LV8.6 folder
3. Open the folder “inside 1.0 BIN” and copy the file “dtree110vernier.dat” into the LabVIEW shared directory “C:\Program Files\National Instruments\Shared\Example Finder\1.0\BIN”.
4. Open the folder “inside 1.0 Products LV 8.x exbins English” and copy the file “VernierWin.bin3” into the LabVIEW shared directory “C:\Program Files\National Instruments\Shared\Example Finder\1.0\Products\LabVIEW\8.x\exbins\English”.
5. Open the folder “inside examples” and copy the folder “Vernier” into the LabVIEW directory “C:\Program Files\National Instruments\LabVIEW 8.x\examples”.
6. Open the folder “inside menus Categories” and copy the folder “Vernier SensorDAQ” into the LabVIEW directory “C:\Program Files\National Instruments\LabVIEW 8.x\menus\Categories”.
7. Open the folder “inside vilib” and copy the folder “Vernier” into the LabVIEW directory “C:\Program Files\National Instruments\LabVIEW 8.x\vi.lib”.

Start LabVIEW and Collect Data with SensorDAQ

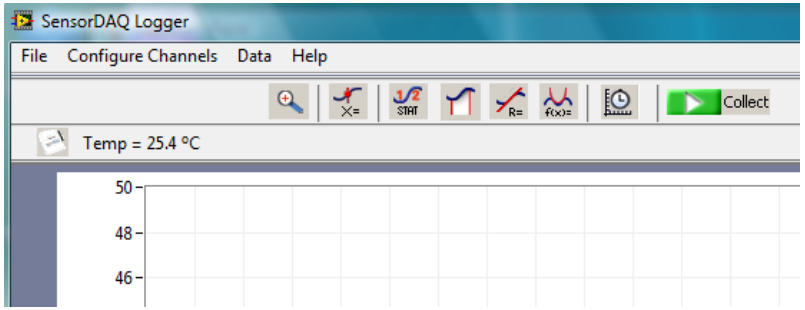
The following example is an advanced LabVIEW program that is very useful for testing your equipment and collecting data. To find information on our many LabVIEW example programs go to the section called SensorDAQ Example VIs.

6. Connect a Vernier Auto-ID sensor to Ch. 1.
7. Start LabVIEW
8. Open the NI Example Finder by choosing Find Examples from the Help menu.
9. Select Directory Structure in the upper-left corner.
10. From the list of folders, choose Vernier.
11. Open the folders SensorDAQ LabVIEW Examples » Log and Analyze Data » Log with Analysis and single-click the SensorDAQ Logger.vi to view the description of this example in the Information box.



12. Double-click SensorDAQ Logger.vi to open it.
13. Start the example by clicking LabVIEW’s white Run arrow in the upper left corner.

    Tip: If LabVIEW has successfully detected the SensorDAQ, you will see the device icon appear in the upper left corner (see below), along with the sensor reading. In this example a temperature probe was connected.



14. Click the Collect button . LabVIEW will begin plotting data in the graph.
15. Once data have been collected, click and drag the mouse on the graph to highlight data. Click on the various analysis buttons in the toolbar (Zoom, Examine, Statistics, Integrate, Linear Fit, and Curve Fit) to study your data.
16. Stop this VI by selecting Exit from the File menu.

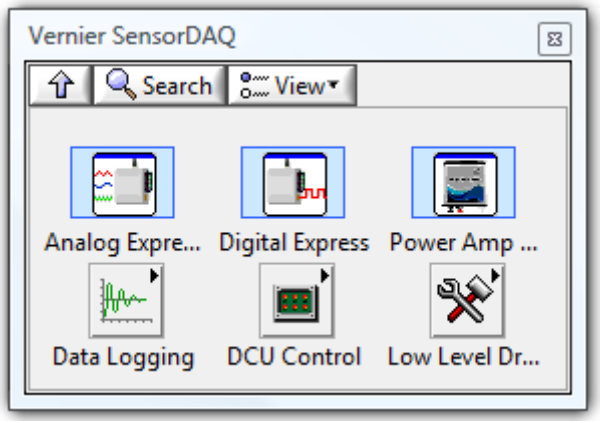
You have now successfully set up your equipment, collected data, and performed analysis. Keep reading for information on the hardware, the LabVIEW examples, and the SensorDAQ palette.

SensorDAQ Palette

The SensorDAQ is a device that is designed to be programmed using LabVIEW development software. Use the SensorDAQ palette of Express VIs and driver VIs to communicate with the device and perform control and data logging. Combine this with all of the power of LabVIEW to create custom programs, perform data analysis, generate reports, post to the web and more.

The information below refers to the SensorDAQ files that are installed with LabVIEW version 2009 or newer. Older versions of LabVIEW do not have the complete set of Express VIs.

Accessing the SensorDAQ Palette



As you customize an existing SensorDAQ example (or even if you are building a new program from scratch) you will need access to the SensorDAQ Express VIs and driver VIs. These are located in the functions palette and are placed on the block diagram by clicking and dragging. The functions palette is accessed in LabVIEW by selecting View » Functions Palette or right-clicking in the block diagram workspace. If you do not immediately see the SensorDAQ palette click on the Search button at the top of the functions palette and search "SensorDAQ". If there are no SensorDAQ results in the search the SensorDAQ files were not properly installed.

Analog Express

This Express VI should be your starting point for learning how to program the SensorDAQ. It allows you to test your hardware and build a useful LabVIEW program in a quick and clean method. Simply click and drag the Analog Express VI into the block diagram. The Express VI will provide a configuration window that allows you to configure all five analog inputs, view and modify the calibration coefficients, zero the sensor reading, choose the sensor units, set the data-collection rate, length of the experiment, as well as any triggering.

Click the Help button in the Analog Express VI's configuration window for information on how to use this Express VI to build your LabVIEW VIs.

Digital Express

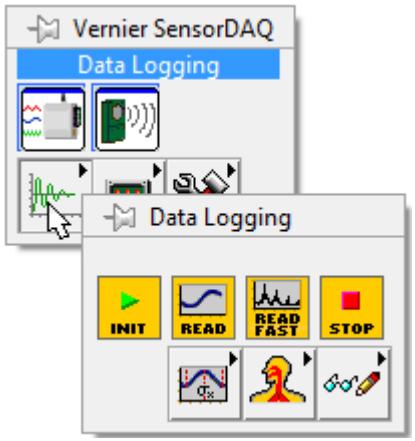
Use this Express VI to configure data acquisition from the Vernier Motion Detector, Photogate, DCU, and Rotary Motion Sensor connected to the DIG Channel. Simply click and drag the Analog Express VI into the block diagram. The Express VI will provide a configuration window that provides feedback on your hardware connections.

Click the Help button in the Digital Express VI's configuration window for information on how to use this Express VI to build your LabVIEW VIs.

Power Amp Express

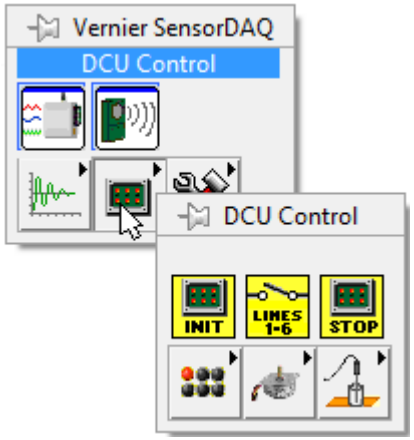
Use this Express VI when using the Vernier Power Amplifier connected to the SensorDAQ Analog Output screw terminal. The Power Amplifier allows you to amplify the SensorDAQ output up to 10V, as well as drive loads that require up to 1 ampere of current.

Data Logging



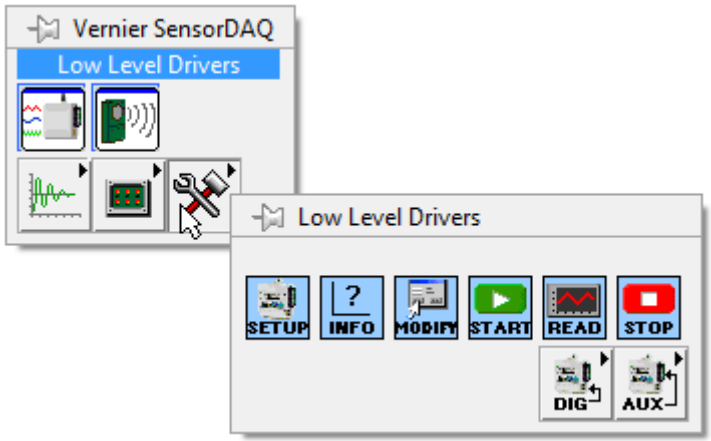
The data logging palette of subVIs are designed for building LabVIEW programs that have the features and analysis required for classroom experimentation. View the examples in the Data Logging folder to see how these driver VIs, analysis VIs, and Utility VIs can be used.

DCU Control



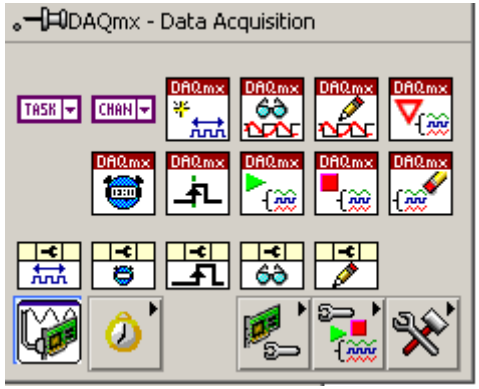
The Vernier Digital Control Unit (DCU) is a piece of hardware that connects to the SensorDAQ DIG Channel and provides useful current to digital output lines. The DCU Control VIs allow you to easily build programs for controlling these output lines, including outputs based on sensor readings and outputs required for stepper and servo motors.

Low Level Drivers



In most cases the Express VIs, the DAQ Assistant, the Data Logging palette, and the DCU palette provide the flexibility and power you will need for creating your custom SensorDAQ program. The Low Level Driver VIs may be useful if you do require more flexibility, and there are many examples in the example folder with the name Advanced Low Level that show how to use this palette. However, these examples also add more complexity.

DAQmx API



The DAQmx device driver software will install a DAQmx API that is available in the LabVIEW programming environment. This palette, found in the Measurement I/O palette, provides the most flexibility and power for communication with SensorDAQ. Of course, it also means increased complexity. For most users the SensorDAQ drivers and Express VIs provide the appropriate flexibility, ease-of-use, and power, and the DAQmx API will

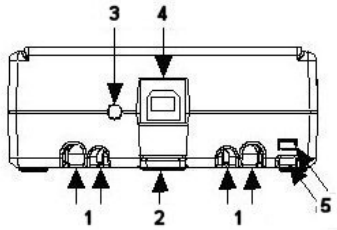
not be used or viewed. However, if you have experience using DAQmx API, or if you require the low-level flexibility, we have provided some examples that show how to use DAQmx API with SensorDAQ. They are labeled Advanced Low Level in the example folders. There are a few differences in configuring a DAQmx task for the SensorDAQ sensor channels that can be seen in the examples, such as setting up the channel names of these channels.

DAQ Assistant

The NI-DAQ Assistant is an Express VI wrapper of the NI DAQmx API, installed with NI-DAQmx device driver software, found with the DAQmx API in the Measurement I/O palette. The DAQ Assistant supports the screw terminal channels of SensorDAQ, and is a great way to program these channels. However, the DAQ Assistant does not support the Sensor Channels. Use the SensorDAQ Analog Express VI as an alternative Express VI for configuring the Sensor Channels.

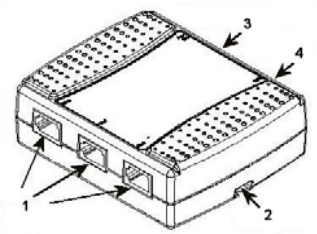
SensorDAQ Components

SensorDaq features four channels to connect Vernier sensors (three analog, one digital) as well as a screw connector providing two analog input (AI) channels, one analog output (AO) channel, four digital input/output (DIO) channels, and a 32-bit counter/timer (PFI).



SensorDAQ back view

1. The **USB Cable Strain Relief** is used to ensure a secure USB connection.
2. Use the **Mounting Slot** and **Panel Mount** to mount SensorDAQ to an object.
3. The **LED** blinks when SensorDAQ has power and is recognized by the DAQmx driver.
4. The **USB Port** is for computer connection.
5. Use the **Tie Wrap Point** to lock down and secure the device.



SensorDAQ side view

1. Ch.1–Ch.3 **BTA (British Telecom Analog) channels** for Vernier analog sensors. The Vernier voltage probe is an analog sensor.
2. Use the **Mounting Slot** and **Panel Mount** to mount SensorDAQ to an object.
3. The **Screw Terminal Connector** is available for customized input and output. The screw terminal can be removed after being wired for specific experiments. Replacement terminals are available from Vernier.
4. DIG **BTD (British Telecom Digital) input/output channel** for Vernier digital sensors.

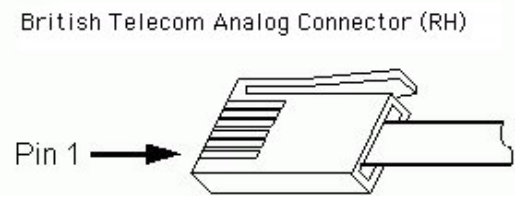
Providing Power to SensorDAQ

SensorDAQ is powered by the USB cable from the computer.

Connecting Sensors and Signal Lines

Vernier Analog Sensors

Sensors can be divided into two basic types—analog and digital. Examples of analog sensors are Voltage, Temperature Probes, pH Sensors, Force Sensors, and Oxygen Gas Sensors. Up to three analog sensors can be connected to SensorDAQ at any time[1]. The channels for the analog sensors (Ch.1–Ch.3) are located on the left side. The analog ports accept British Telecom-style plugs with a right-hand connector.

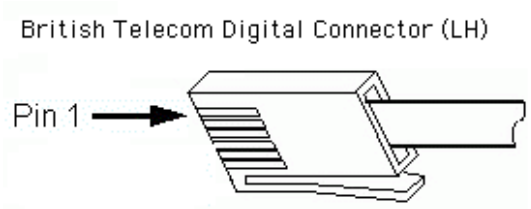


Pin 1 = Sensor output (+/-10V)
Pin 2 = GND
Pin 3 = Vres (resistance reference)
Pin 4 = AutoIDENT (used for auto-ID of most Vernier sensors)
Pin 5 = Power (+5VDC)
Pin 6 = Sensor output (0-5V)

[1] Due to the high power consumption of some Vernier CO2 Sensors, only one CO2 Sensor can be used at a time with SensorDAQ.

Most sensors provided by Vernier are auto-ID sensors. When you plug an auto-ID sensor into SensorDAQ, the software will be able to identify it and set up the file accordingly. Auto-ID information includes default settings for data collection rate, length of collection, and calibration coefficients.
Most Vernier analog sensors send a raw voltage signal in the range of 0-5V on pin 6. A few send a signal in the range of ±10V on Pin 1. The raw voltage signal is converted to proper units using the sensor's calibration coefficients.
Most Vernier sensors that plug directly into SensorDAQ without an adapter are auto-ID. However, the SensorDAQ can read a 0-5V or ±10V signal from many types of sensors. To make the connection to SensorDAQ with a sensor without a BTA plug, use an adapter (www.vernier.com/adapters/), or a bare BTA cable (order code BB-BTA) wired to your custom sensor.

Vernier Digital Sensors



Pin 1 = I/O1
Pin 2 = I/O2
Pin 3 = I/O3
Pin 4 = PWR (5.08V)
Pin 5 = GND
Pin 6 = I/O4

Examples of digital sensors are Motion Detectors, Photogates, and Rotary Motion Sensors. One digital sensor at a time can be connected to SensorDAQ. The digital channel (DIG), which accepts British Telecom-style plugs with a left-hand connector, is located on the opposite side of the analog channels.

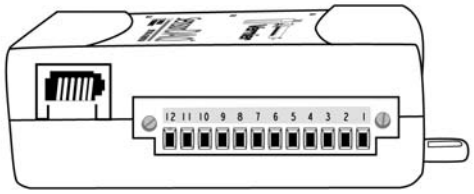
The SensorDAQ's DIG Channel also accepts a Vernier Digital Control Unit. This is a small box with a short cable that uses the DIG channel to provide output (up to 600 mA of current) for controlling electrical devices.

Screw Terminal

SensorDAQ screw terminal connectors can be used for input or output. When used for output, these connectors provide a limited current (see specs below); therefore, in some cases you will have to provide an external power source. The +5V terminal can be used as your voltage source. This source can only supply 200 mA maximum.

Note: *A convenient option for running devices using digital output lines is the Vernier Digital Control Unit (DCU). The DCU plugs directly into the DIG channel and can supply up to 600mA of useful current to output lines. In addition, the Vernier Power Amplifier (order code PAMP) can be used with the screw terminal outputs to drive loads up to 1 A.*

The table below describes the signals available on the screw terminals.



Screw terminal connector pinout

Terminal	Signal Name	Reference	Direction	Description
5,8,10	GND	—	—	**Ground**: Reference point for single-ended AI measurements, bias current return point for differential mode measurements, AO voltages, digital signals at the I/O connector, +5 VDC supply, and the +2.5 VDC reference.
11,12	AI <0..1>	Varies	Input	**Analog Input Channels 0 and 1**: For single-ended measurements, each signal is an analog input voltage channel. For differential measurements, AI 0 and AI 1 are the positive and negative inputs, respectfully, of differential analog input channel 0.
9	AO 0	GND	Output	**Analog Output Channel 0**: Supplies the voltage output of AO channel 0 from 0-5V with an output current drive value of 5 mA. The maximum update rate is 150 Hz, software timed.
1-4	P0.<0.3	GND	Input or Output	**Digital I/O Signals**: You can individually configure each signal as an input or output.
6	+5 V	GND	Output	**+5 V Power Source**: Provides +5 V power.
7	PFI 0	GND	Input	**PFI 0**: This pin is configurable as either a digital trigger, an event counter input, pulse generation output, or as a period, semi-period, two edge separation timer.

Analog Input Wiring
In the differential input setting, connect the the positive lead of the source to the AI(0) terminal, and the negative lead to the AI(1) terminal. The differential input mode allows the SensorDAQ to measure a voltage difference on these terminals up to +20V or –20V in the ±20V range; however, the maximum voltage on any one terminal cannot exceed ±10 V with respect to GND. In the referenced single-ended input mode setting, connect the positive lead of the source to either AI channel terminal, AI(0) or AI(1), and the ground or negative lead to the GND terminal.

Analog Output Wiring
The SensorDAQ has one AO channel that can generate an output from 0–5V. The AO has an output current drive value of 5 mA. The maximum update rate of the channel is 150 Hz, software timed. To connect loads to the SensorDAQ, connect the positive lead of the load to the A0 terminal, and connect the ground lead of the load to a GND terminal.

Digital I/O
In addition to supporting Vernier digital sensors, the SensorDAQ has four digital lines, P0.<0..3>, which comprise the DIO port. GND is the ground-reference signal for the DIO port. The default configuration of the SensorDAQ DIO ports is open collector, allowing 5 V operation, with an onboard 4.7 kΩ pull-up resistor. An external, user-provided, pull-up resistor can be added to increase the source current drive up to 8.5 mA limit per line.

Counter/Timer
SensorDAQ has a counter/timer that can be configured for pulse output, timing input, event counting, or as a digital trigger.

SensorDAQ Example VIs

The best way to get started with SensorDAQ is to open and run examples. You can use the examples without modification for data logging with analysis, for control, to perform output, to troubleshoot your hardware, and as starting points for your own custom program.

The SensorDAQ examples are located in the LabVIEW\examples\Vernier directory. An easy way to find the examples is to launch the LabVIEW Example finder. The Example Finder is launched by selecting Find Examples from the Help menu. Select Directory Structure in the upper-left corner, and locate the Vernier folder.

The examples are stored in descriptive folders. Locate the folder that best matches your sensor or how you plan to use the hardware. For best results, explore all of the example folders and open a sampling of examples. Inside the folders you may find examples labeled Starter. Open these examples first. They are designed as a starting point for testing the hardware and learning the LabVIEW code. There may also be subfolders that are labeled Advanced Low Level. In general, these examples will only be useful if you require a higher level of flexibility for communicating with the SensorDAQ.

The folders are explained below:

Digital Control Unit (DCU)

The Vernier DCU connects to the DIG Channel and provides output lines that can control small electric devices. This is a great device for classroom projects or discussion of sensor control. In this folder you will find examples showing how to control the output lines, how to control lines based on sensor readings going above or below threshold values, and how to control servo and stepper motors connected to the DCU.

Feedback and Control

The SensorDAQ screw terminal provides digital input and output, analog input, analog output and pulse output. The examples in this folder provide examples of feedback and control using the screw terminal channels.

Log and Analyze Data

These are examples that are great for running science and engineering-type experiments in the classroom. In this folder you will find examples with the features required for collecting data and performing some type of analysis on the data including; linear fit, curve fit, integral, statistics, tangent, and more. In addition you will find examples for creating XY graphs, performing events with entry, saving data to file, building tables, zeroing a sensor reading, changing sensor units and more.

Inside this folder is a LabVIEW example VI called “SensorDAQ Logger.vi”. This is an advanced example where Channels 1-3 can be used to collect data with Vernier analog sensors, and the screw terminal inputs AI0 and AI1 can be used to collect data with custom analog sensors. These five analog inputs can be configured, and the calibration coefficients modified. Clicking on the Data Collection button configures the data-collection rate, length of the experiment, as well as any triggering. Once data have been collected, there are some analysis features that can be used. If you would like to analyze a small portion of the data, simply click and drag your mouse to highlight the

region, or use the Zoom tool to zoom in or zoom out. Data can be stored and deleted to compare against other runs, as well as saved to file.

Motion Detector

The Vernier Motion Detector connects to the DIG Channel. We have created an Express VI for the Motion Detector that can be used to create quick, simple and clean LabVIEW examples. If you are using the Motion Detector, start by viewing the Express VI examples in this folder.

Physiology Sensors

Vernier provides sensors such as blood pressure, ekg, heart rate, respiration monitor, and spirometer. These examples are similar to the examples located in the Data Logging folder. They provide the features that allow you to collect and analyze the data. Of course the analysis in these examples is specific to the sensor.

SDAQ Analog Sensors

The examples in this folder show how to read data from analog sensors. The Analog Express VI is the focus of these examples because it provides a very simple, quick and clean method for programming the analog sensors. If you are just getting started with SensorDAQ, with LabVIEW, or with teaching how to program the SensorDAQ, the Express VI and these examples should be the starting focus.

SDAQ Digital Sensors

This folder contains examples for the Vernier Photogate, Radiation, and Rotary Motion sensors. The Vernier DCU and Motion Detector are also digital sensors, but have their own folder of examples that were detailed above.

SDAQ Pulse Output

The SensorDAQ has two counters as part of the hardware. One counter is available on the screw terminal, and the other is hidden on the DIG Channel. To access the hidden line, connect the DCU to the DIG Channel; line 1 of the DCU is the pulse output line. These counters can be used to provide a pulse output or a pulse train. The examples demonstrate how to do this.

SDAQ Screw Terminal

These are examples that demonstrate analog input, analog output, counter counting and timing, digital input and digital output from the screw terminal channels. You will find additional screw terminal examples in the Feedback and Control folder.

NI Measurement and Automation Explorer (MAX)

If you have worked with other National Instruments hardware and LabVIEW software, you may be familiar with MAX.

MAX is a software application that is installed with NI-DAQmx device driver software. This application can be used to determine if the SensorDAQ hardware and NI-DAQmx software have been properly installed. MAX Test Panels can also be used to test the SensorDAQ channels. However, only the screw terminal channels will appear in the pull-down list of Channel Names. The Vernier Sensor Channels will not automatically appear in the list. You can manually enter the Sensor Channel names and still perform a test. For a common Vernier Sensor connected to Ch.1, that reads from the 0-5 Volt sensor line the inputs are as follows:

Channel Name: "Dev1/_sensor0_5V"
Max Input Limit: 5 Volt
Min Input Limit: 0 Volt
Input Configuration: RSE

For a Vernier Sensor that reads from the +-10 Volt sensor line (Voltage Probe and Microphone) the inputs are as follows:

Channel Name: "Dev1/_sensor0_10V"
Max Input Limit: 10 Volt
Min Input Limit: -10 Volt
Input Configuration: RSE

Resources

The following manuals and resources provide detailed information about SensorDAQ and LabVIEW.

Learning LabVIEW
Vernier has released a book called *Hands-On Introduction to LabVIEW with Vernier*. This book introduces NI LabVIEW programming through a series of hands-on exercises using Vernier sensors and SensorDAQ, LabQuest or LabQuest Mini. Besides learning the basics of NI LabVIEW programming,

your students will get started collecting and analyzing data. This book requires LabVIEW 2009 or newer.

Engineering Projects with LabVIEW
Vernier has released a new book called *Engineering Projects with NI LabVIEW and Vernier*. This book contains engaging hands-on projects for SensorDAQ, LabQuest, or LabQuest Mini. It introduces engineering concepts and programming with LabVIEW. An introductory knowledge of NI LabVIEW programming is assumed. This book requires LabVIEW 2009 or newer.

SensorDAQ Specifications
This guide, available on the SensorDAQ CD and online, describes SensorDAQ technical specifications.

DCU Manual
The Digital Control Unit (DCU) gives you an easy way to use SensorDAQ's digital channel for exciting, do-it-yourself projects.

Math Machines
Math Machines www.mathmachines.net creates customized connector and control experiments for teachers using SensorDAQ.

National Instruments LabVIEW Support
The National Instruments web site is a complete resource for LabVIEW software support. Go to www.ni.com/academic/learn_labview to find resources for learning LabVIEW.

Troubleshooting

- If the SensorDAQ LED does not blink, the NI-DAQmx driver may not be properly installed. Try re-installing the driver. Reboot the computer after installing the driver.
- If the SensorDAQ LED is blinking, but the LabVIEW examples do not detect SensorDAQ, you may have installed a version of NI-DAQmx that is not compatible with your version of LabVIEW or your computer OS. Open NI's Measurement and Automation Explorer application to determine the DAQmx version. You may need to update your version of NI-DAQmx from www.ni.com.
- There is a problem with some high-speed USB connections on computers running Windows 7. The symptom of this problem is that the LabVIEW VI, or the Analog Express VI, will read from an analog sensor for a few seconds and then lose communication with the sensor. Stopping the VI, unplugging and then reinserting the USB cable into the computer, and then restarting the VI will fix communication with the sensor, but again, for only a few seconds. If you experience this problem you will have to first update to NI DAQmx version 9.4 or newer. Following this, you must replace a SensorDAQ file. Open the folder called Win7 USB Fix on the SensorDAQ CD. Locate the VI found in this folder called SensorDAQ-ConfigAITask.vi. Use this VI to replace the VI with the same name, found in the LabVIEW directory at C:\Program Files\National Instruments\LabVIEW 20XX\vi.lib\Vernier\SensorDAQ\Low Level Drivers\SensorDAQ subVIs.
- If the SensorDAQ LED is blinking, but the LabVIEW examples do not detect SensorDAQ, unplug SensorDAQ's USB cable, reboot the computer, then reinsert the USB cable to SensorDAQ.
- There was a reported bug in NI-DAQmx version 9.1 through 9.2.1 that may cause the driver to be unable to find the SensorDAQ hardware. Install a newer version of NI-DAQmx or install the patch found at www.ni.com.
- A bug in NI-DAQmx caused the rotary motion sensor to only be able to read angles in one direction. This was to be fixed in version 9.3.
- The USB cable, or the USB port of the computer may not be responding properly. Try a different cable and a different port.
- If you create a LabVIEW VI with the DAQ Assistant you must run the VI with the same SensorDAQ that was connected to the computer when you configured the DAQ Assistant. Switching SensorDAQs will cause an error when you run your program. Delete the DAQ Assistant and reconfigure a new DAQ Assistant, or go to MAX and update the device number of the SensorDAQ.

NOTES

SensorDAQ User's Manual